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INVESTIGATION OF ULTRASONIC WELDING OF REFRACTORY METALS AND ALLOYS

January 1963

Prepared under Navy Bureau of Naval Weapons
Contract No. NOw 63-0125-c

Bimonthly Progress Report No. 2
16 October 1962 through 16 December 1962

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AEROPROJECTS INCORPORATED
WEST CHESTER, PENNSYLVANIA

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ABSTRACT

The programming of ultrasonic welding power is shown to be straightforward. Similar control of clamping force involved employment of various hydraulic circuitry prior to achievement of acceptable response time. Use of an alternate valve component in the hydraulic system is to be investigated for result comparison purposes. Problems relative to establishment of specifications for quality refractory metals are mentioned.

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INVESTIGATION OF ULTRASONIC WELDING OF REFRACTORY METALS AND ALLOYS

The ultrasonic welding cycle involves an induction period wherein the sonotrode tip slips during the establishment of coupling, and an interval wherein tip amplitude may decrease as the weld is generated. The slip interval produces heat that is probably unnecessary, and the interval of amplitude decline seems to be associated with high cyclic stresses in the weldment. The programming of power and clamping force will operate to reduce power, to improve welding control, and to extend the utility of the process. Thus, the work here discussed is concerned with power-force programming and to the specific objective of joining refractory metals.

The division of the work and development effort is presented in the program control chart included elsewhere in this report.

A summary of the work executed during this period follows:

Power-Force Programming Equipment

A. Power Programming

The output power level of a standard 4-kilowatt ultrasonic spot welder is controlled by varying the amplitude of the high-frequency signal supplied to the power amplifier stages of the generator. Step control of this signal level is straightforward. Measurements show that output power follows variations in amplitude of the applied signal faithfully, and that the response, from the instant the control signal is applied until the output power has actually changed, is less than 0.002 second.

This response is within the presently envisioned requirements, and a power-programming control circuit is being assembled on this basis.

B. Force Programming

The hydraulic system of a 4-kilowatt welder has been modified so that the applied clamping force can be rapidly increased or decreased by varying the oil pressure on the welder's primary force pistons. Figure 1A schematically illustrates the system. The rapid force-changes implicit in force-programming will be effected by controlling by-pass oil flow (see dotted line of Figure 1A) thus increasing or decreasing oil pressure, beyond the manually adjustable pressure valve (Q), that is delivered by the motor and hydraulic pump (Z).

Figure 1B summarizes response data already obtained on three flow-control valves.

Curve A summarizes data obtained with a standard General Controls magnetic, solenoid-controlled, tapered-seat-type valve. A part of the delay (up to 0.050 second) is the time required to overcome the hydraulic pressure which normally aids in the sealing or closing of this valve type.

Curve B presents summary response data on the performance of a high-response, shear-seal valve (Barksdale Valve Co.), and Curve C shows similar information realized when a standard continuous by-pass valve (designated Q in Figure 1) was replaced with a Republic Manufacturing Co. Model G50, 2-1/2-inch pressure-control ball-check valve.

Figure 2 shows an actual strip-chart oscillogram of the variation of the force when a step signal is applied. The high-response, shear-seal valve responded between 0.016 and 0.020 second after application of the electrical signal, and the drop in force occurred about 0.008 second later. The response on the rise was again 0.020 second after removal of the electrical signal, with pressure build-up in about 0.060 second.

A second approach, presently in test, involves control of the necessary force by a servo-valve. This valve is controlled by a servo amplifier which responds to command signals from the program control circuit.

The response with the use of the servo-valve will be compared to that realized with the shear-seal valves. The better of the two methods will be used.

Weldment Materials

An intensive study of available refractory metals information shows that the quality of these newer metals, and in particular their sub-surface contamination, probably contributes greatly to difficulties encountered in the ultrasonic welding thereof.

Efforts to establish procurement specifications for refractory metals of satisfactory quality are continuing. Letters requesting assistance in this work have been sent to the various suppliers. The General Electric Company, Cleveland, Ohio, was visited to discuss methods of material process control. The conclusions of this conference were:

1. General Electric has experienced non-uniformity and impurity problems with both molybdenum and Mo-0.5Ti.

2. General Electric will supply test materials of considerably more uniform quality, as free from surface contamination as possible.

Quotations for the necessary quantities of each material in the highest quality attainable have been solicited. To date, replies have been received from two vendors only.

Miscellaneous

Program Planning and Execution

A schedule incorporating the important elements of this development has been established (Figure 3). The interval between the date of the contract documents and the receipt thereof necessitates a considerable consolidation of effort during the April, May, and June work period. Every attempt will be made to adhere to the established control schedule, and modifications will be made thereto only if essential.

Future Work

1. PFP circuitry, for both the time base control and power and force control, will continue to be assembled and tested.

2. Efforts to obtain the highest quality materials will continue. Orders will be placed for limited quantities of each alloy of interest.

3. Preliminary non-PFP welding of the control alloys (stainless steel and Inconel X) will be initiated.

REFERENCES

1. Aeroprojects Incorporated, "Ultrasonic Welding of Refractory Metals", under Navy Contract No. NOw-61-0410-c.

2. Aeroprojects Incorporated, "Development of Ultrasonic Welding Equipment for Refractory Metals - Phase II", under Air Force Contract No. AF 33(600)-43026.

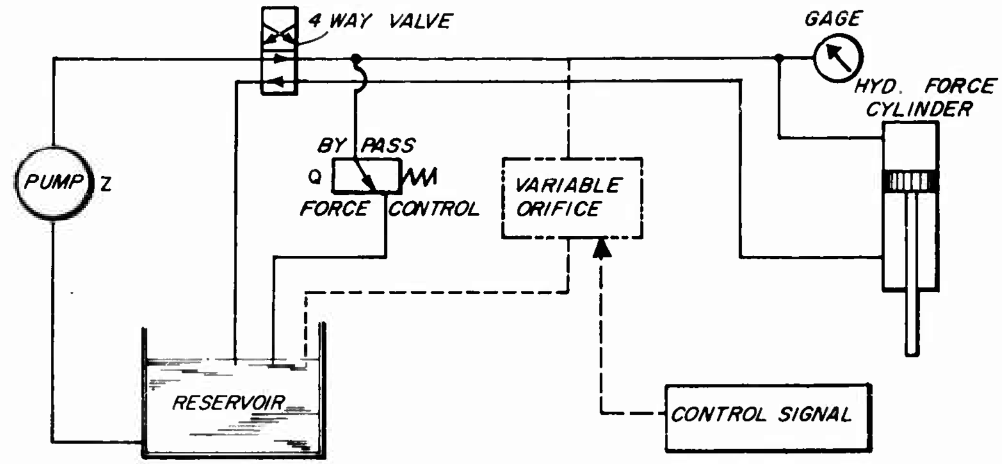

Figure 1A

HYDRAULIC CIRCUIT FOR STANDARD ULTRASONIC WELDER

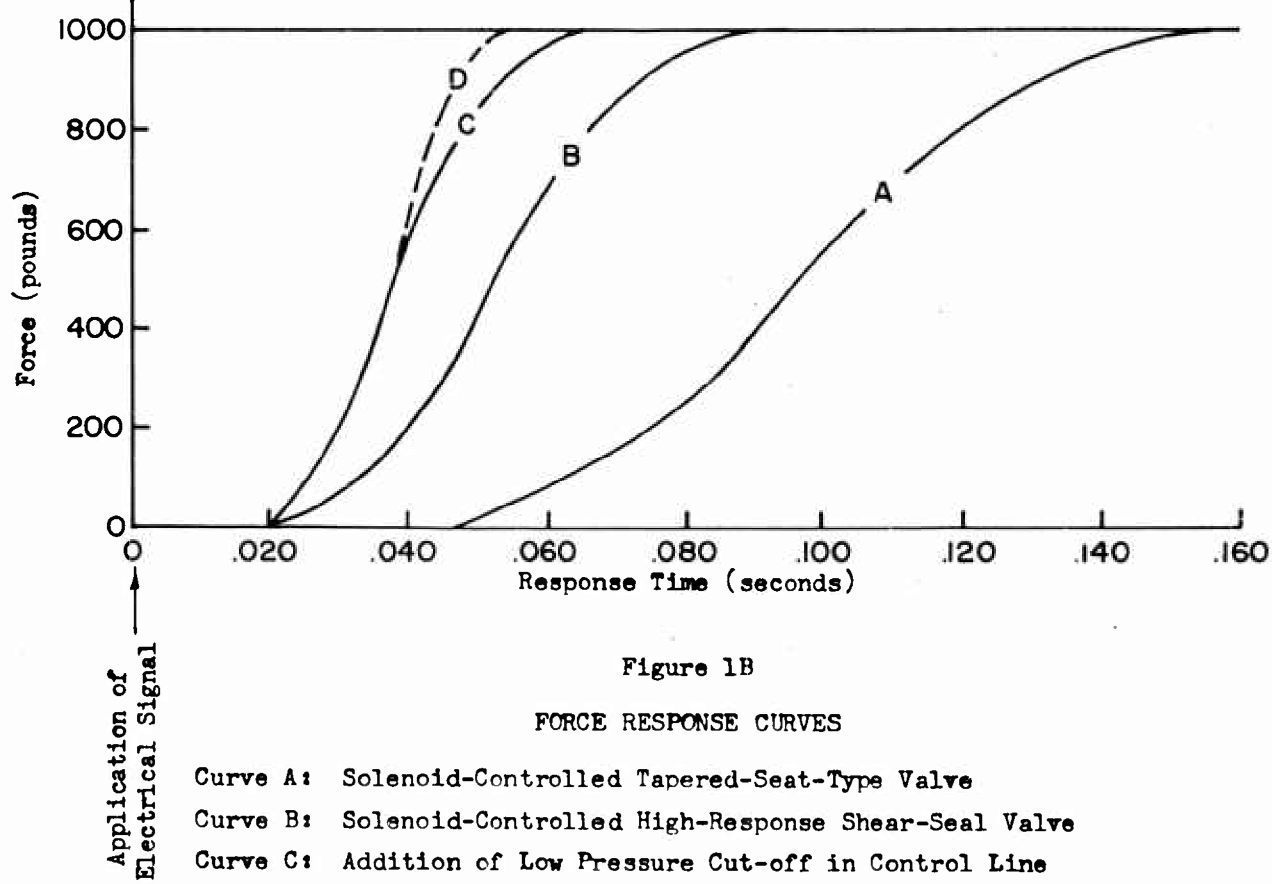

Figure 1B

FORCE RESPONSE CURVES

Curve A: Solenoid-Controlled Tapered-Seat-Type Valve

Curve B: Solenoid-Controlled High-Response Shear-Seal Valve

Curve C: Addition of Low Pressure Cut-off in Control Line

Curve D: Estimated Response with Addition of Pressure Accumulator

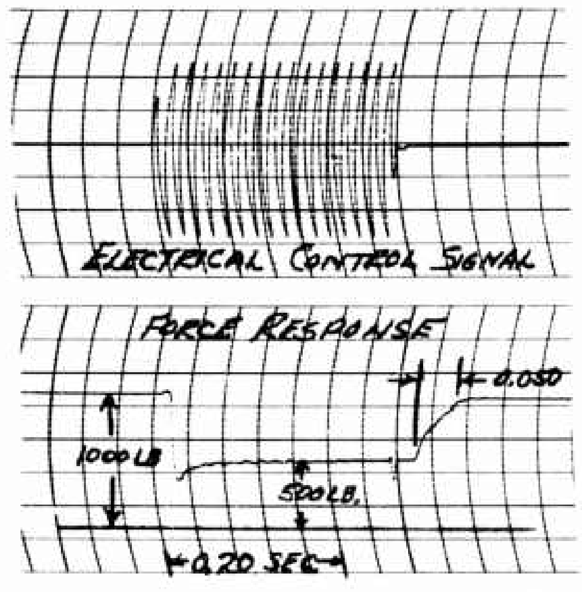

Figure 2

TYPICAL FORCE RESPONSE CURVE TO SINGLE STEP CONTROL FUNCTION WITH 60-CYCLE PACING SIGNAL

Phase No.	
1	Preliminary Engineering and Tentative Equipment Specifications
2	Welder Components
3	Establish Specifications for Control Materials
4	Establish Specifications for Mo-0.5Ti
5	Establish Specifications for Selected Refractory Metals
6	System Development
7	Control Materials
8	Mo-0.5Ti
9	Selected Refractory Metals
10	Establish Welder Settings
11	Control Materials: Weld and Evaluate
12	Prepare, Weld and Evaluate Mo-0.5Ti
13	Selected Refractory Metals
14	Establish Optimum Welder Settings
15	Equipment Modification if Necessary
16	Weld Mo-0.5Ti: Modify Equipment

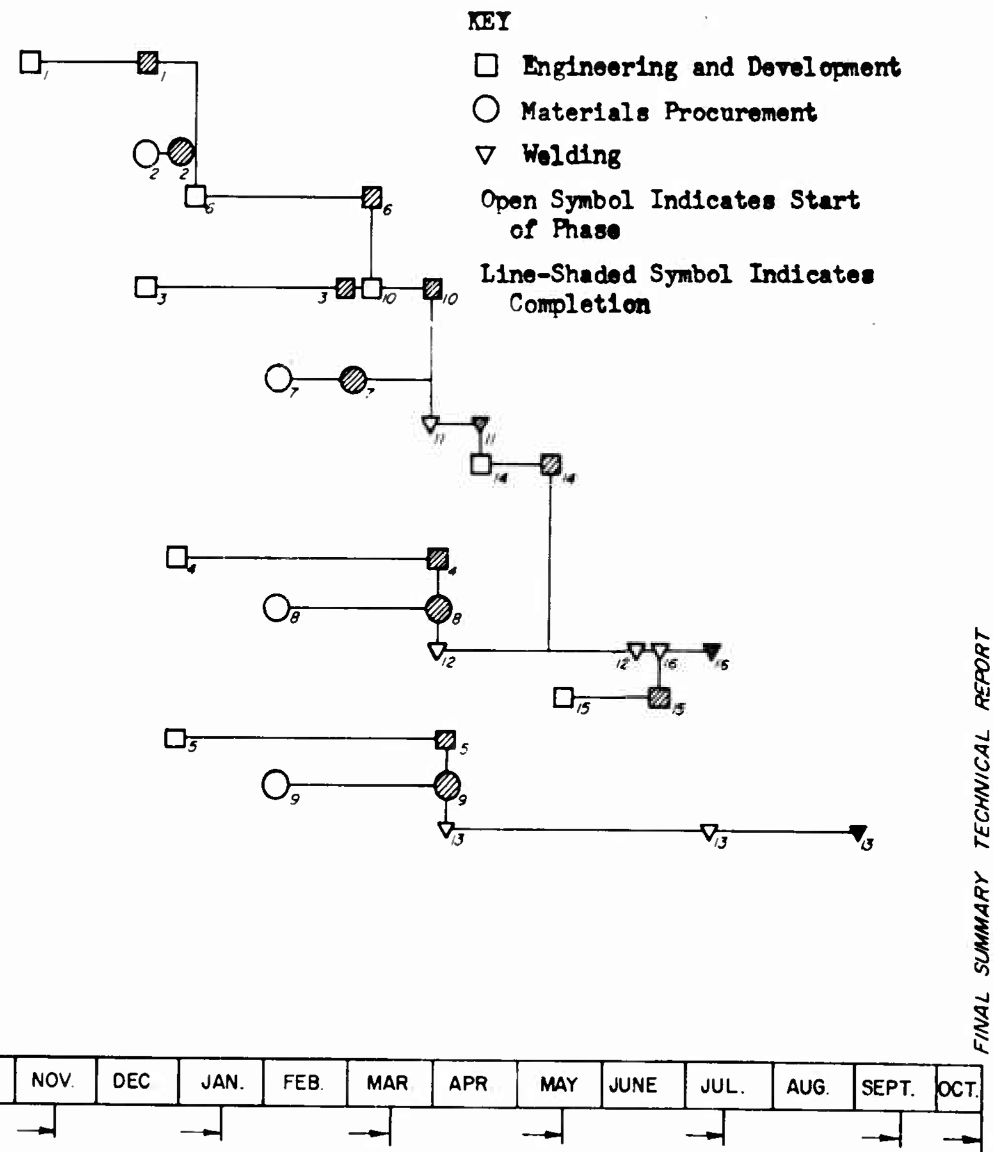

Figure 3

INVESTIGATION OF ULTRASONIC WELDING OF REFRACTORY METALS WITH POWER-FORCE PROGRAMMING

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